EVALUATION OF RADON CONCENTRATION LEVELS IN SELECTED OFFICES OF IBRAHIM BADAMASI BABANGIDA UNIVERSITY, LAPAI, NIGER STATE, NIGERIA AND CONCOMITANT HEALTH HAZARDS

M. Bashir[a] , I.K. Suleiman[a], M. T. Kolo[b], A. Muhammad[a]
[a]Department of Physics, Ibrahim Badamasi Babangida University Lapai, Nigeria.
[b]Department of Physics, Federal University of Technology Minna, Nigeria.
Corresponding author. Email: bashirmunirat@yahoo.com

Abstract
Environmental level of radioactive radon was measured in selected offices of two prominent buildings of Ibrahim Badamasi Babangida University, Lapai, Niger State. The measurement was done using a standardized RAD7 continuous radon monitor. Radon concentration levels for the offices in the administrative building varied between 13.1±3.1 and 44.1±5.6 Bqm^{-3} with a mean value of 22.8 ± 4.0 Bqm^{-3}, while the variation in concentration for the offices in the FMSS building was from 8.6 ± 3.6 to 25.3 ± 5.6 Bqm^{-3} with an average value of 15.3±4.2 Bqm^{-3}. These values were below the world average value of 40 Bqm^{-3}. Computed mean annual effective dose to the lungs for the admin building and FMSS building were 0.55 and 0.46 mSvy^{-1} respectively. Although the radon levels obtained in all the offices evaluated were found to be below the permissible reference levels, there is need for accurate consciousness of the danger of radon accumulation in apartments. Adequate ventilation and other necessary mitigation measures should be put in place to keep the radon concentration levels as low as reasonably achievable.

Keywords: Radon concentration, RAD7 monitor, IBBU, annual effective dose, Niger state

1. Introduction

Radon (^{222}Rn) is the most predominantly found radioisotope in human dwelling environment. It is a naturally occurring tasteless, odourless and colourless radioactive gas which emanates from uranium present in rocks, soils and many ground formations (Afolabi et al., 2015).

Radon gas is ubiquitous in human environment, with increased concentrations indoors in homes and workplaces where most exposure of the general population occurs (Kpordzro et al., 2022). Pervin et al (2022), reported that meteorological parameters, topography, types of building materials and nature of ventilation has great influence on the concentration of indoor radon. Molecular and gaseous diffusion of radon through pore spaces, convection via cracks and openings, off-gassing of waterborne radon into the indoor environment and radon entrance from air outdoor are additional mechanisms that can enhance the level of indoor radon (Pervin et al., 2018; Lee et al., 2020). Gunby (1993) also reported that building materials especially quartz and cement can significantly influence the level of natural radioactivity in closed places. Most residential homes and workplaces especially in developing countries like Nigeria are often built without any radon resistant facilities, which can result in high level of exposure to indoor radon (Afolabi et al., 2015).

The most prominent cause of lung cancer aside tobacco smoking, according to world health organization report, is human exposure to indoor radon (WHO, 2009). Epidemiological studies have long-established the prevalence of lung cancer due to radon exposure at homes and in work places. Long-time exposure to radon can result in enough damage to the pulmonary mucosa leading to cancer. Studies in Europe, North America, and China have confirmed that a low concentration of radon such as those commonly found in residential settings poses a health risk and contributes to the occurrences of lung cancers worldwide (Darby et al., 2005; Kpordzro et al., 2022). Serious attention must therefore be given to indoor radon from the perspective of human health.

Information on radon gas and its deleterious effect on the health of human population is very scarce especially in the northern part of Nigeria. It is therefore of utmost importance that the human susceptibility to radon exposure especially in residential homes and work environments be investigated. This research is thus aimed at assessing the indoor radon levels in selected offices of IBBU and evaluating the effective dose to human population as a result of their exposure.

2. Materials and method

Ibrahim Badamasi Babangida University (IBBU) is a state owned institution which was founded in 2005. It is located in Lapai town, Lapai local government are of Niger state (Figure 1). This institution, which is run and managed by the Niger state government, has about seven faculties.

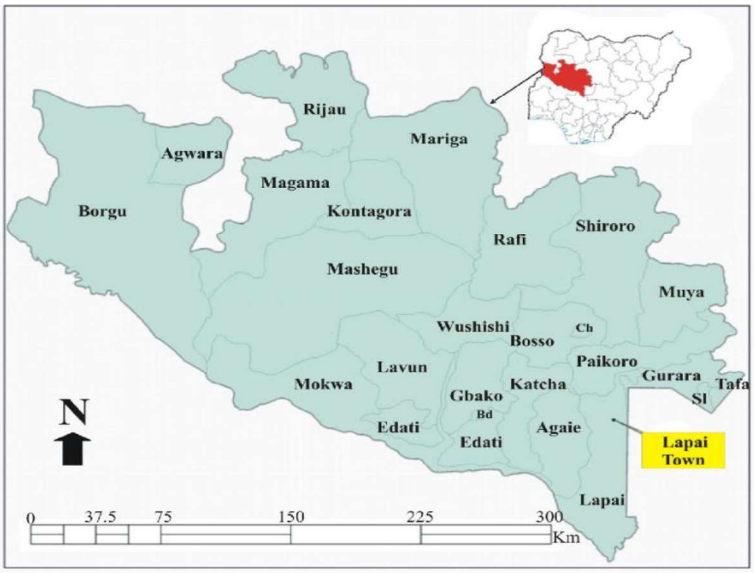

Figure 1 Map of Nigeria showing Lapai town, Niger State

Ten (10) offices in two most prominent buildings of the University: the Administrative (Admin) building and FMSS building, were randomly selected for preliminary indoor radon concentration measurement using a standardized RAD7 continuous radon monitor manufactured by Durridge Company, USA. The setup was such that the monitor was placed about 1 m above ground and only radon gas (^{222}Rn) was allowed by diffusion, to enter through the glass filter into the ionization chamber. Average radon concentration for each office within the period of measurement was computed by an in-built personal computer (PC) Software called CAPTURE.

The annual effective dose (D_R) due to indoor radon in the offices was evaluated using the equation (UNSCEAR, 2000):

$$D_R \text{ (mSv y}^{-1}) = C_{Rn} \times D_c \times OF \times I_f \times T \qquad (1)$$

where the radon concentration, C_{Rn} is measured in Bqm^{-3}, the dose conversion factor D_c is taken as 9×10^{-6} $mSvh^{-1}$ $(Bqm^{-3})^{-1}$, OF and I_f are the indoor occupancy factor (0.4) and radon equilibrium factor indoors (0.4) respectively, and T is the hours in the year (7008) (ICRP, 2010). Furthermore, the resulting annual effective dose (ED) to the lungs incurred by the occupants due to exposure to indoor radon was estimated using the equation:

$$ED \text{ (mSvy}^{-1}) = D_R \times W_R \times W_T \qquad (2)$$

where D_R is the annual effective dose in mSv y^{-1}, W_R is the radiation weighting factor for alpha particles (20) and W_T is the tissue weighting factor (0.12) for the lungs (ICRP, 1993)

3. Results and discussion

Indoor radon concentration along with the temperature and relative humidity of all the offices investigated are presented in table 1. Also presented in table 1 are the computed annual absorbed dose (D_R) and annual effective dose (ED) due to the measured radon level. The six offices of admin building investigated are on the ground floor while the remaining four investigated offices are on the first floor of the FMSS building. Average temperature of the offices in the two buildings at the time of investigation was 29°C, with the FMSS building recording higher mean relative humidity of 71.2%.

Radon Concentration

As seen in table 1, radon concentration on the ground floor offices ranged from 13.1±3.1 to 44.1±5.6 Bqm^{-3}, with a mean value of 22.8 ± 4.0 Bqm^{-3}, while the average radon concentration on the first floor was 15.3±4.2 Bqm^{-3}. Radon level at the ground floor was about 33% higher than at the first floor, which according to Ptiček et al. (2020), may be due to the fact that most radon comes from the ground which is directly in contact with the ground floor. The temperature variations on the two floors (ground floor and first floor) appears to be uniform which suggests that the effect of temperature on radon levels at the two floors is negligible.

Table 1 Indoor Radon Concentration with temperature, humidity, annual absorbed dose and annual effective dose of Admin and FMSS office buildings in IBB University

LOCATION	CODE	FLOOR	VENTILATION	T (◦C)	RH (%)	C_{Rn} (Bqm^{-3})	D_R (mSv/y)	ED (mSv/y)
ADMIN BUILDING	GF1	Ground floor	Normal	28	55.3	23.9±3.9	0.24	0.58
	GF2	Ground floor	Normal	28.4	65.5	13.1±3.1	0.13	0.32
	GF3	Ground floor	Normal	29.3	68.5	13.1±3.4	0.13	0.32
	GF4	Ground floor	Normal	30.4	64.6	18.0±3.6	0.18	0.44
	GF5	Ground floor	Normal	28.7	64.3	24.7±4.1	0.25	0.60
	GF6	Ground floor	Normal	29	70.3	44.1±5.6	0.45	1.07
	Mean			29.0	64.8	22.8±4.0	0.23	0.55
FMSS BUILDING	FF1	First floor	Normal	29.4	70.9	12.3±3.0	0.16	0.37
	FF2	First floor	Normal	29.9	70.3	14.9±4.7	0.19	0.45
	FF3	First floor	Normal	28.2	71.9	8.6±3.6	0.11	0.26
	FF4	First floor	Normal	29.7	71.5	25.3±5.6	0.32	0.77
	Mean			29.3	71.2	15.3±4.2	0.19	0.46

Mean radon concentration values for the offices on the two floors were lower than the world average value of 40 Bqm^{-3} (Ali et al., 2013; UNSCEAR, 2000). The values were also below the reference level of 100 Bqm^{-3} proposed by the world Health Organization to reduce radiation health incidence as a result of exposure to indoor radon (WHO, 2009). Furthermore, the level of ventilation across all the offices investigated is appreciably normal which might have contributed to the low level of radon in all the offices.

Annual absorbed dose (D_R) and Annual effective dose (ED)

Columns 8 and 9 of table 1 shows the computed D_R and ED for all the investigated offices. D_R for the admin building varied from 0.13 to 0.45 $mSvy^{-1}$ with a mean of 0.23 $mSvy^{-1}$, while that for the FMSS building ranged between 0.11 to 0.32 $mSvy^{-1}$, with an average value of 0.19 $mSvy^{-}$

^{1}. The corresponding average ED for the two buildings were 0.55 and 0.46 $mSvy^{-1}$ respectively. Although the mean ED value for the admin building (ground floor) is slightly higher than that for the FMSS building (first floor), the mean ED for the two buildings are below the world average of 1 $mSvy^{-1}$ for normal radiation background. The likelihood of any radiation incidence that may demand urgent intervention is therefore insignificant.

4. Conclusion

This research presents the results of a preliminary and baseline survey of radon concentration levels in offices on the administrative (admin) and FMSS buildings of Ibrahim Badamasi Babangida University Lapai, Niger State. Average radon levels for the two buildings were 22.8±4.0 and 15.3±4.2 Bqm^{-3} respectively, with corresponding mean AED of 0.23 and 0.19 $mSvy^{-1}$ in sequence. Although the values were below the recommended threshold for public safety, proper ventilation in all the office buildings is recommended to keep the radon level as low as reasonably achievable.

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